TETRA TECH

Memorandum

To:	Ashraf Habbak, PE City of Redmond
From:	Selene Fisher, PE Tetra Tech
cc:	Steve Hitch, PE City of Redmond Dean Franz, PE Greg Woloveke Tetra Tech
Date:	Draft: December 14, 2015 Final: January 12, 2016 Addendum: May 12, 2016
Subject:	NE 50th Way Drainage Improvement – Storm Conveyance Analysis Summary
Project:	100-SET-13-049J

The updated pipe hydraulic information in the Addendum reflects the final storm pipe design profile for the project which was completed in May 2016. This is provided in the appendix at the end of this Memorandum.

1.0 INTRODUCTION

Tosh Creek in southwest Redmond is an approximately 146 acre watershed tributary to the Sammamish River. The creek has been identified as a restoration priority by the City for both aquatic habitat and flood protection. The Tosh Creek Watershed Restoration Plan (TCWRP) identified NE 50th Way as needing infrastructure improvements to reduce flooding.

NE 50th Way near West Lake Sammamish Parkway NE is subject to regular flooding and requires frequent maintenance and emergency response from stormwater maintenance crews. A small seasonal stream, called NE 50th Way Creek, located in the Native Growth Protection Area adjacent to NE 50th Way, floods primarily when driveway culvert inlets plug with debris. During floods, homeowners frequently attempt to clear debris submerged under several feet of water. When emergency response crews are mobilized, it takes several hours to stop the flooding.

To characterize conveyance deficiencies and propose conveyance improvements, Tetra Tech developed hydrologic and hydraulic models of the existing and proposed drainage system. This memo documents results of the modeling and identifies recommended stormwater conveyance improvements.

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2.0 DESIGN STANDARDS

Per Redmond Municipal Code 15.24.020, stormwater management design standards are as defined in the Technical Notebook; Chapter 8 provides the Local Design Standards. Additional requirements are found in the Redmond Standard Specifications and Details. Design standards specific to stormwater systems are summarized in Table 1.

Table 1 – Redmond Stormwater Conveyance Design Standards

Item	Standard
Pipe Sizing	
Design storm – general	10-year fully-developed
Culvert under a City ROW	25-year fully-developed
Adjacent properties not flooded	50-year event
Minimum pipe size	12 inches public; 6 inches private
*Catch Basin/Manhole Freeboard **	
10-year storm	12 inches
25-year storm	6 inches
50-year storm	0 inches (no overtopping)
Minimum Ground Cover	
Storm sewer pipe	18 inches
Ductile iron pipe	12 inches
Storm Drain Line Slope	
Maximum slope	20%
Minimum slope	0.25%
Catch Basin/Manhole Spacing	
Pipe diameter < 12-inch or Flow velocity < 3 fps	200 feet
Pipe diameter < 30-inch with Flow velocity >3 fps	300 feet
Pipe diam. > 30-inch & < 42-inch with Flow velocity > 3 fps	400 feet
Pipe diameter > 42-inch with Flow velocity > 3 fps	600 feet
Tight lines down steep slopes	600 feet
All bends, changes in pipe size or material, and at pipe junctions	Install structure
Utility Clearance	
Horizontal	5’ distance between storm drains (pipes and structures) and water, gas, or sewer (pipes and structures)
Vertical	Storm drains 12” above or below electrical, phone, fiber optic, water main or gas main. Storm drains 12” above sanitary sewer or 18” below sanitary.

* Per City direction at the December 14, 2015 meeting, the freeboard requirement for this project is the 10-year/12-inches standard only.

3.0 MODEL DEVELOPMENT

As specified in the Technical Notebook, hydrologic modeling shall utilize a continuous simulation program, and hydraulic modeling shall utilize a backwater analysis program; WWHM and PC-SWMM, respectively, were used in this analysis.

3.1 HYDROLOGIC MODEL

The Western Washington Hydrologic Model (WWHM) was used to develop peak discharge rates for the design events. WWHM is a continuous-simulation model maintained by the Department of Ecology. Stormwater runoff is simulated from pervious and impervious land surfaces, soil moisture dynamics, and hydrologic routing on a continuous basis. WWHM was selected for this project because it has built-in local soil and land use parameters and provides long-term rainfall records for specific regions in Western Washington.

The hydrologic model requires four inputs: watershed delineation, hydrologic soil group, slope, and land-use. The watershed delineation was identified as subbasin 10 in the TCWRP. For this study, the TCWRP's subbasin 10 boundary was modified along the southeast border. Examination of the topography and local knowledge determined that the southeast edge would drain into Tosh Creek Tributary A, rather than to the NE 50th Way Creek. Approximately one acre was removed from the subbasin area. The watershed was further delineated into 8 subbasins based on topographical drainage pathways and differences in slope and land-use. The final basin boundary encompasses 31.5 acres and is shown in Figure 1.

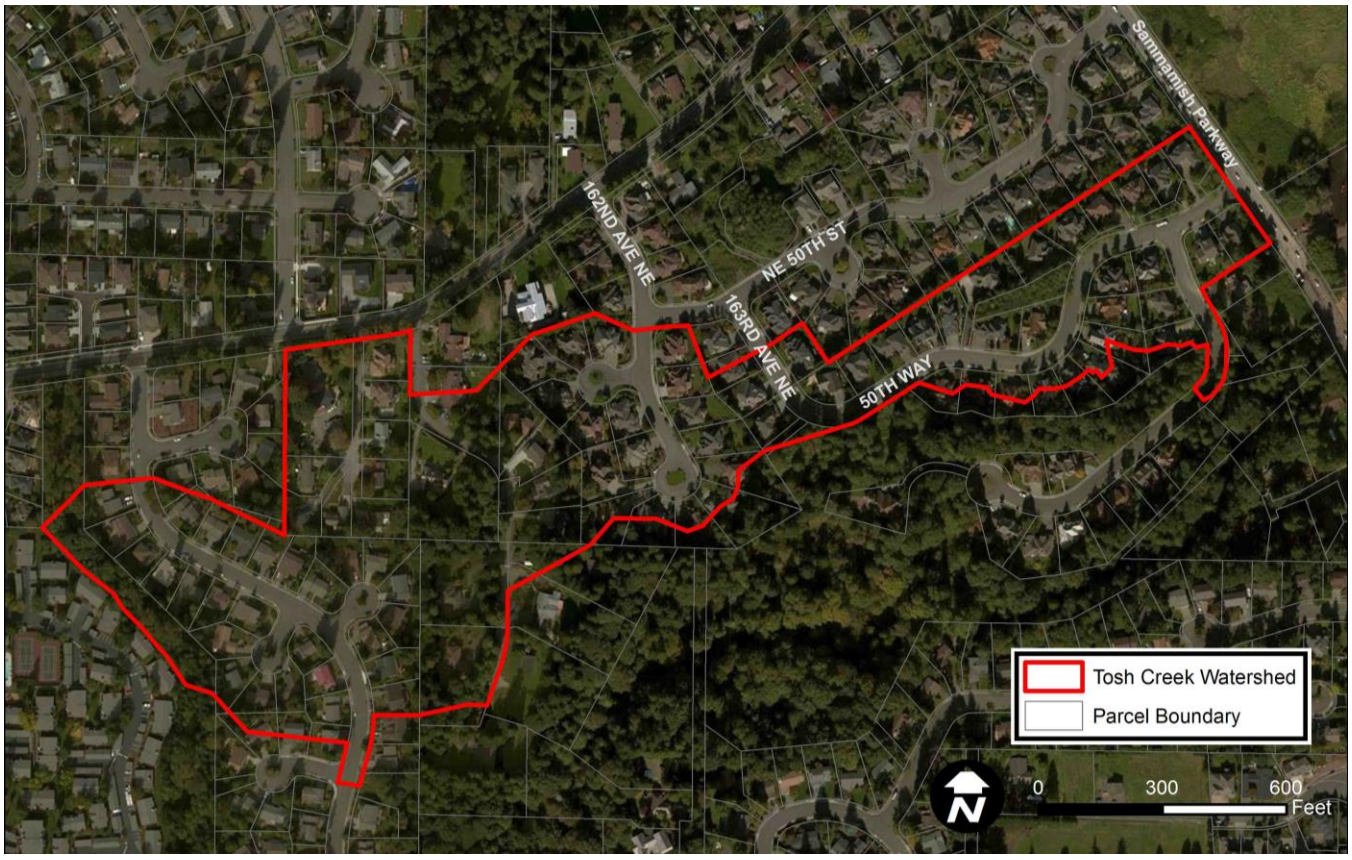


Figure 1. Tosh Creek Subbasin 10 delineation with southeast border modified from TCWRP boundary

Soils information was acquired from the NRCS SSURGO database. Hydrologic soil groups represent the potential for infiltration based on the surficial soil classification and range from Group A soils having low runoff potential and high infiltration rates to Group D soils having high runoff potential with negligible infiltration rates. The entire watershed is characterized by Type C hydrologic soils: Alderwood gravelly sandy loam and Kitsap silt loam. These soils have moderate to poor drainage hindered by an underlying low permeability layer.

Slope was developed using ArcMap 10.1 and created from 2014 LiDAR obtained from the City of Redmond. Slope is divided into three categories: low (<5 percent), moderate (5-15 percent), and high (>15 percent).

Land-use was delineated using a combination of roof footprints and road rights-of-way boundaries to define impervious area as measured in the aerial photo. Much of the NE 50th Way Creek watershed showed a high degree of effective impervious area for private parcels, meaning most impervious areas are connected directly to the drainage system via roof or driveway drains. To account for the additional impervious area associated with each home (driveways, patios, etc.), the roof area in these subbasins was increased 50 percent based on site reconnaissance and aerial photo review. All remaining land area was defined as pervious.

WWHM defines pervious areas as lawn, pasture, or forest and applies runoff and infiltration characteristics to match these definitions. In the NE 50th Way Creek watershed, pervious area was modeled as 'lawn' with the exception of subbasin 6 and subbasin 7. Subbasin 6 displays a large potential for ineffective impervious area: most areas are not connected to the storm drain and there is a high proportion of heavy tree cover. Except for the roadway footprint, the subbasin was modeled as 'forest' that drains into a small stream before entering the storm drain system. Subbasin 7 drains a small neighborhood drained by a private storm system. Roofs are poorly connected and lots are not highly developed; with the exception of the roadway footprint the subbasin was modeled as 'pasture'. The land use definition coverage in the watershed is shown in Figure 2.

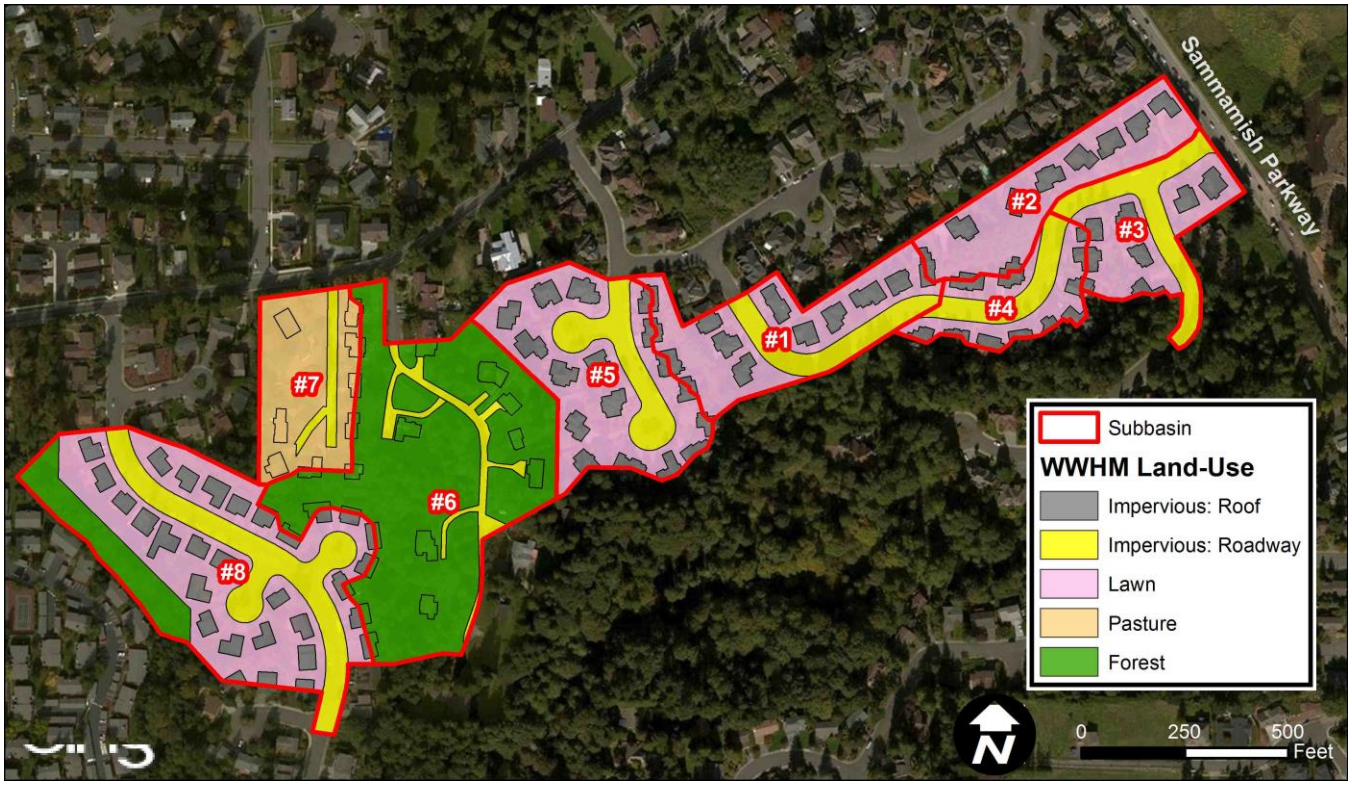


Figure 2. WWHM subbasin and land-use delineation

The land use and slope data were processed using ESRI ArcMap 10.1 to intersect coverages; the resulting areas shown in Table 2 become model inputs. The resulting peak discharge rates from WWHM are provided in Table 3.

Table 2 – WWHM Hydrologic Inputs

Land use/Slope Category	Subbasin (acres) 1	2	3	4	5	6	7	8
Lawn / Low Slope	0.14	0.01	--	--	--	--	--	0.22
Lawn / Moderate Slope	0.94	0.70	0.39	0.34	1.78	--	--	1.78
Lawn / High Slope	0.42	0.98	0.54	0.24	0.27	--	--	0.27
Forest / Low Slope	--	--	--	--	--	1.95	--	0.10
Forest / Moderate Slope	--	--	--	--	--	3.89	--	0.43
Forest / High Slope	--	--	--	--	--	1.66	--	0.46
Pasture / Low Slope	--	--	--	--	--	--	0.57	--
Pasture / Moderate Slope	--	--	--	--	--	--	1.21	--
Pasture / High Slope	--	--	--	--	--	--	0.30	--
Impervious: Road	0.73	0.02	0.95	0.57	0.84	0.61	0.27	1.67
Impervious: Roof Plus	0.99	0.82	0.58	0.54	1.40	--	--	1.95
Subtotal Area	3.21	2.53	2.44	1.64	4.29	8.11	2.35	6.89
Total Area	31.46							

Table 3 – Hydrologic Results

Subbasin ID	10-Year Peak Flow (cfs)	25-Year Peak Flow (cfs)	50-Year Peak Flow (cfs)
1	1.22	1.47	1.66
2	0.83	1.03	1.19
3	1.02	1.21	1.36
4	0.72	0.85	0.95
5	1.61	1.94	2.19
6	0.72	0.91	1.06
7	0.30	0.39	0.47
8	2.42	2.88	3.24

3.2 HYDRAULIC MODEL

PC-SWMM was used to simulate existing and proposed hydraulic conditions. PC-SWMM is a front-end application using the EPA-SWMM hydraulics engine and provides additional tools to automate model development. Using the City's stormwater geodatabase, storm drain and catch basin characteristics were geo-referenced into the model. Information imported for model development includes: pipe inverts, pipe length, pipe material, pipe diameter, catching basin inverts, and rim elevations. Information included in the stormwater database was validated against Marymoor Hill as-built plans provided by the City of Redmond and the Dowl survey base map; differences were resolved with field inspection.

Stormwater detention vault characteristics were input using as-built details provided by the City of Redmond. Vaults are located at the outlet of subbasin 8 and subbasin 3. The subbasin 8 vault was modeled as the detention pipe diameter with outflow restricted by an orifice as described in the as-built. The subbasin 3 vault was modeled as a four-orifice and one-overflow-weir control structure between the inlet and outlet pipes.

Because no surface grate was located and no flooding has been reported, one catch basin in subbasin 1 was modeled as 'bolted' to simulate the increased hydraulic head associated with a sealed lid. This was done by allowing the model structure to surcharge without loss of flow. Overflows connections were added to simulate gutter flow when water surface elevation exceeds rim elevation. Stream channel geometry was approximated from field observations.

Flows developed using WWHM were assigned input locations based on subbasin boundaries. Flows were input as steady-state values with no hydrograph or storm volume. Subbasin 7 flows were applied directly to subbasin 6. The runoff from subbasin 1 was halved and entered into two locations in the subbasin.

The catch basins were numbered consecutively from downstream to upstream and labeled with a prefix "U" for catch basins above the outfall to NE 50th Way Creek and with a prefix "D" for catch basins below the outfall down to the stormwater vault. An overview of the hydraulic model of the conveyance network is provided in Figure 3.

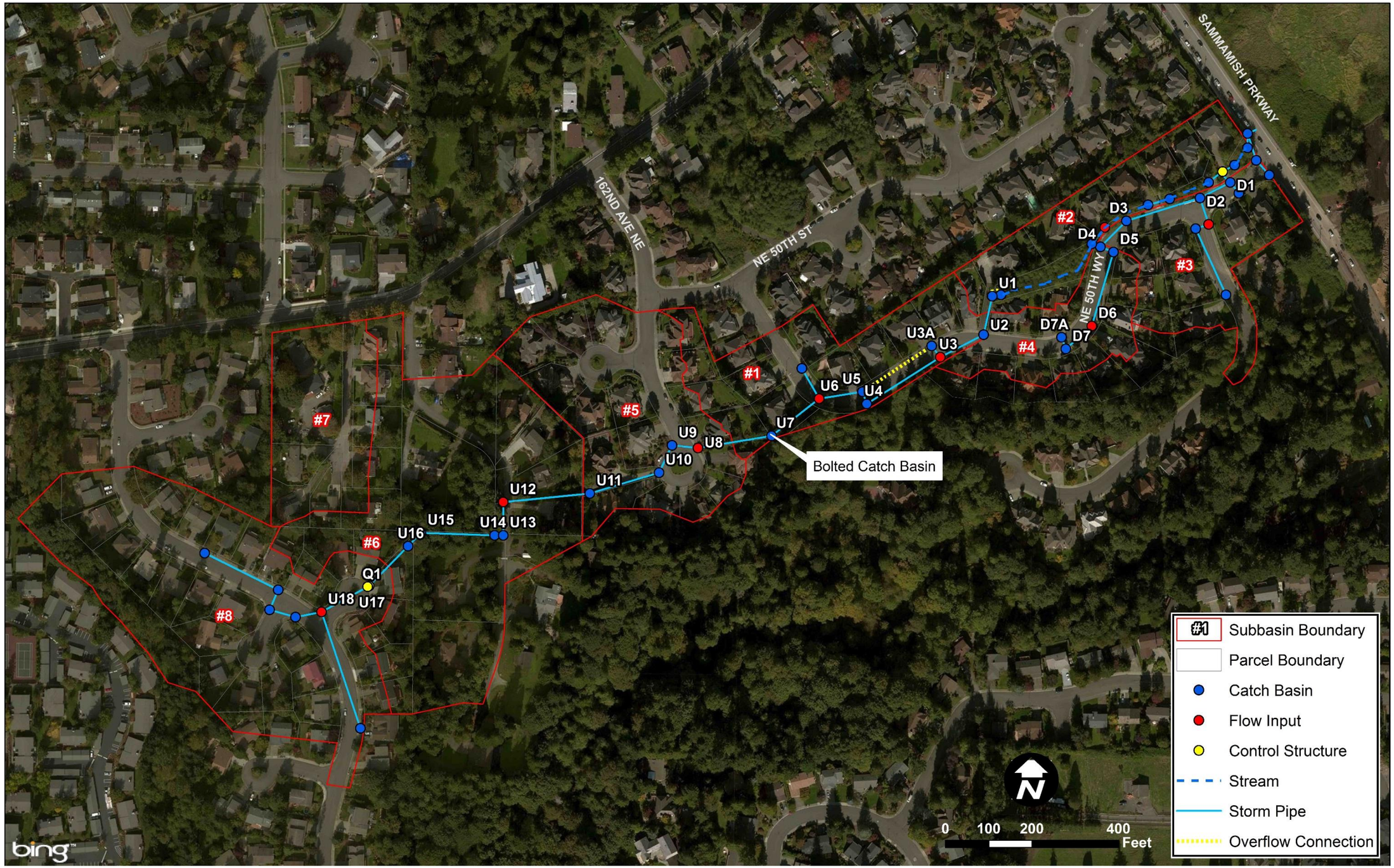


Figure 3 – SWMM Model with Labeled Nodes

4.0 STORMWATER CONVEYANCE RESULTS – EXISTING

Table 4 lists the resulting hydraulic grade line (HGL) and difference from the rim elevation for the 10-year design flow. A negative number indicates the stormwater is below the rim elevation. In the upper watershed, one catch basin (U8) on 162nd Court NE has a positive difference, meaning runoff is calculated to pool to a depth of 1.6 inches in the gutter at the peak runoff condition. Since this area is outside the project area of interest, detailed hydraulic system modeling was not performed to investigate this predicted ponding; instead, the water is captured and routed downstream for conveyance capacity evaluation. These results illustrate that there is potential available capacity to divert high flows from the NE 50th Way Creek into the downstream pipe network.

Table 4 – Hydraulic Results for 10-year Flood (Existing)

Catch Basin ID	Rim Elevation (ft)	HGL (ft)	Difference (ft)
U11	195.37	190.26	-5.11
U10	178.97	177.17	-1.80
U9	174.9	174.53	-0.37
U8	172.58	172.71	0.13
U7 (bolted)	155.96	--	
U6	154.49	150.15	-4.34
U5	148.80	147.17	-1.63
U4	149.08	145.67	-3.41
U3	142.39	139.18	-3.21
U2	137.31	134.84	-2.47
U1	130.68	129.72	-0.96
D7	126.31	122.83	-3.48
D6	119.35	116.25	-3.10
D5	100.03	97.42	-2.61
D4	100.03	96.77	-3.26
D3	92.59	89.46	-3.13
D2	73.12	69.17	-3.95
D1	62.88	59.93	-2.95

Elevations are NAVD88

5.0 STORMWATER CONVEYANCE RESULTS – PROPOSED DESIGN

The proposed condition is to capture the stormwater on NE 50th Way that currently is routed to the creek and instead convey it down to the West Lake Sammamish Parkway (WLSP) culvert via new and existing stormwater

pipes. Modeling found one pipe (between D5 and D4) to have inadequate capacity to convey the additional upstream flows. The new system, illustrated is Figure 4, which also displays the adjacent utilities, is summarized:

- a new pipe on NE 50th Way near where the current pipe turns and outfalls into the creek (U2' to D7)
- a new parallel system at the downstream end just above WLSP (D1 through D0'' to manhole)
- one replacement pipe for increased capacity (D5 to D4).

The hydraulic model was updated with the new pipes to determine the sizes required to convey the design flows. With the new and upsized pipes, the resulting hydraulic grade line elevations for the 10-year flood event are listed in Table 5.

Table 5 – Hydraulic Results for 10-year Flood (Proposed)

Catch Basin ID	Rim Elevation (ft)	HGL (ft)	Difference (ft)
U11	195.37	190.26	-5.11
U10	178.97	177.17	-1.80
U9	174.90	174.53	-0.37
U8	172.58	172.71	0.13
U7 (bolted)	155.96	--	
U6	154.49	150.15	-4.34
U5	148.80	147.17	-1.63
U4	149.08	145.65	-3.43
U3	142.39	139.89	-2.50
U2'	139.32	136.06	-3.26
U1'	136.84	133.70	-3.14
D7'	129.04	125.83	-3.21
D7	126.31	123.14	-3.17
D6	119.35	116.73	-2.62
D5	100.03	98.93	-1.10
D4	100.03	98.56	-1.47
D3	92.59	89.99	-2.60
D2	73.12	71.79	-1.33
D1	62.88	60.15	-2.73
D0'	57.00	55.57	-1.43
D0''	57.00	54.83	-2.17

Elevations are NAVD88

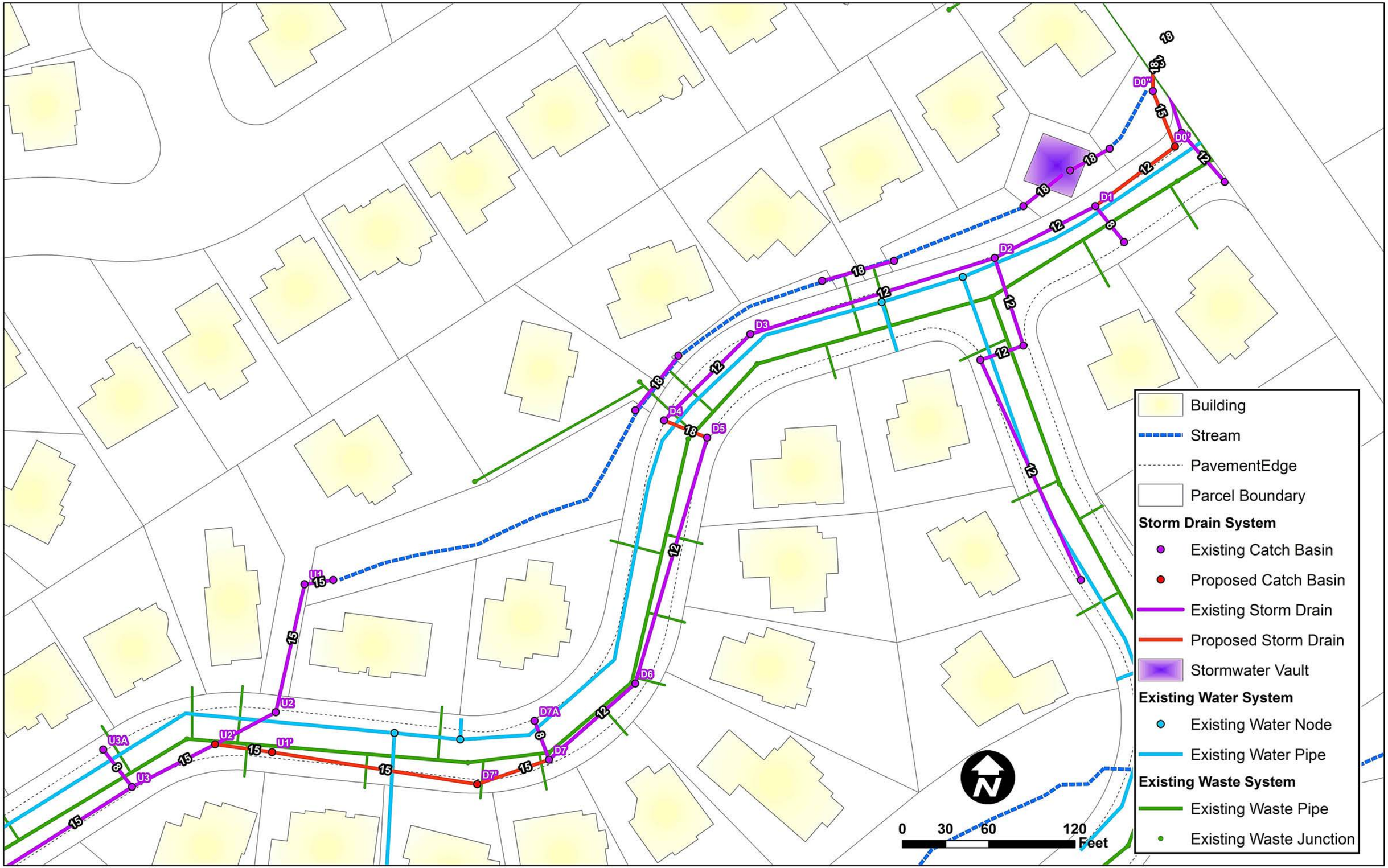


Figure 4 - Proposed Storm Drain Improvements with Utilities

6.0 NEEDS ASSESSMENT

The following conveyance improvements are necessary to convey the 10-year flow along NE 50th Way.

Install flow splitter upstream of discharge point to NE 50th Way Creek (at U2'). Route 1 cfs to creek (via existing pipe to outfall at U1) to maintain base flow in creek as requested by City.

Install new stormwater pipe from flow splitter along south side of NE 50th Way and connect to existing system downstream (U2' to D7).

Length: approximately 250 feet
Size: 15 inches diameter

Number of new structures: 2 or 3

Replace stormwater pipe crossing NE 50th Way from south side to north side (D5 to D4)

Length: approximately 30 feet
Size: 18 inches diameter

Number of new structures: 0 to 2

Install new stormwater pipe on north side of NE 50th Way from catch basin adjacent to downstream stormwater vault to manhole just west of WLSP (D1 through D0'' to manhole).

Length: approximately 70 feet
Size: 12 inches diameter

Length: approximately 70 feet
Size: 18 inches diameter

Number of new structures: 3 or 4

Other elements in drainage system:

Bird cage or offset grate at entrance to stormwater vault on NE 50th Way

TideFlex CheckMate Inline check valve for fish passage prevention

Additional data needs:

Subsurface utility location and depth confirmation (potholing) for proposed new stormwater pipe locations.

Identification/location of water line thrust blocks at water line crossing

7.0 REFERENCES

City of Redmond, NHC, RH2 and Triangle Associates. 2015. Tosh Creek Watershed Restoration Plan. Redmond, WA. February 2015

City of Redmond. 2012. Clearing, Grading, and Stormwater Management Technical Notebook. Redmond, WA. Issue No. 6. February 23, 2012.
Available at: http://www.redmond.gov/Environment/StormwaterUtility/SWTechNotebook2012

City of Redmond. 2015. Standard Specifications and Details. Redmond, WA. July 1, 2015.
Available at: https://www.redmond.gov/cms/One.aspx?portalId=169&pageId=165975

Marymoor Hill Div 3 Vaults, Record Drawing 93-0584, Sheet 5. By Ostergaard Robinson, dated August 4, 1993, latest revision 6-19-95

Topographic Survey NE 50th Way Flood Reduction. By Dowl, dated 10/15/2015.

Tamarack Lane Paving and Drainage, Record Drawing E-0654, Sheet 5. By Stepan and Environment Northwest, dated July 1976, latest revision 9/7/76.

8.0 APPENDIX

Slope distribution for WWHM input

Addendum

The pipe hydraulic analysis has been updated to reflect the final storm pipe plan and profile shown in the construction plans. The pipe plan layout and hydraulic results are summarized on the following pages. The results demonstrate that the storm pipe conveys the design flow without overtopping at the catch basins, and there is a corresponding 1.0 ft. freeboard or greater within each catch basin that is located withn the project limits.

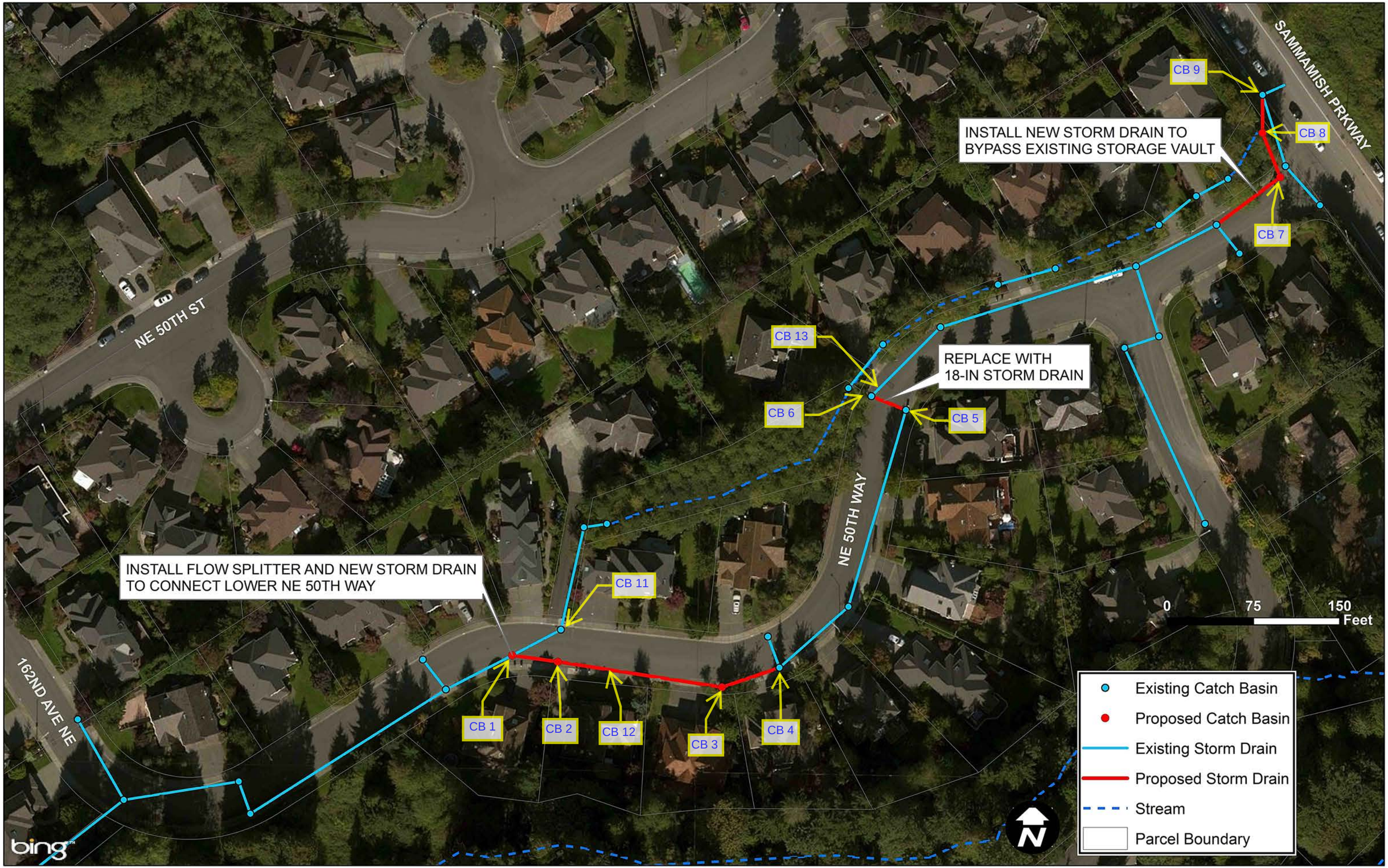
50th Way
Updated Hydraulic Analysis May 2016
10-yr and 50-yr Events

Drainage Structure		10-Year		50-Year	
ID	RIM (ft)	Max HGL (ft)	Freeboard (ft)	Max HGL (ft)	Freeboard (ft)
1	140.70	137.78	2.92	138.75	1.95
2	138.74	135.59	3.15	135.65	3.09
3	130.00	126.86	3.14	126.95	3.05
4	126.31	122.99	3.32	123.09	3.22
5	106.55	103.26	3.29	103.32	3.23
6	103.25	100.59	2.66	100.64	2.61
7	62.86	60.10	2.76	61.02	1.84
8	62.80	56.98	5.82	57.24	5.56
9	57.22	54.55	2.67	54.68	2.54
11	137.20	134.36	2.84	134.38	2.82
12	136.20	128.75	7.45	128.88	7.32

Note: The table shown above demonstrates that there is a 1.0 ft. or greater clearance between the high water elevation (hydraulic grade line) and the catch basin grate elevation, for the 10-yr storm event. This vertical clearance "freeboard" is in compliance with the basis of design criteria established for the project.

For the location of pipe runs and catch basins listed in the table, see the catch basin ID's shown in the following plan sheets.

May 12, 2016 Tetra Tech, Inc.



Summary of Proposed Storm Drain Improvements